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such arrangements had been made, several botanists gave up the trip entirely and collected in the vicinity of Ann Arbor, while those who did go would gladly have left the boat at any one of several points, had it been possible, and been picked up on the return.

We can only assume that this apparent slight of the botanists was due to a supposition on the part of the local committee that the botanists were an insignificant part of the Association, not meriting much trouble or attention. If this is the proper explanation, the registration of over a fifth of the total attendance as members of the Botanical Club must have brought about a change of opinion before the meeting was over.

Proof that Bacteria are the Direct Cause of the Disease in Trees Known as Pear Blight.¹

BY J. C. ARTHUR.

It has now been five years since Professor Burrill brought the subject of pear blight before this Association and announced that it was due to bacteria. Previous to that time no instance of bacteria acting the rôle of vegetable parasites had been known, and the discovery was therefore a very important one, opening the way to a new and promising field of research.

The experiments of Professor Burrill showed that the disease alluded to was invariably accompanied by a specific form of bacteria (since named *Micrococcus amylovorus* Burrill), and that as the disease progressed a colorless or yellowish viscid substance was formed, apparently by the action of the bacteria upon the starch and other substances of the plant. The disease results in the complete death of all those parts of the tree that are attacked.

Although from these and subsequent investigations the theory has been quite generally accepted that the bacteria are the cause of the disease, no rigid proof of it has yet been brought forward. It was with a view to either absolutely prove or disprove the theory that a course of experiments was begun last March, and continued to the present time.

It has been incontestibly shown that the disease may be readily transmitted to healthy tissues by introducing a drop of an infusion made by putting some thin slices of the diseased tissues

¹ Read before the American Association for the Advancement of Science, August, 1885.

in water,² or by simply transferring a minute portion of the exudation from the diseased to the healthy shoot.³ The problem was consequently narrowed down to one of two alternatives, either the bacteria were the cause of the disease, or the juices which accompanied them were the cause of it.

The first attempt was to secure some inoculating material in which the bacteria were entirely freed from the juices of the disease. This was done by means of a succession of artificial cultures in a sterilized infusion of corn (maize) meal.

Two series were successfully carried through, extending over about four months, and an inoculation from the sixth culture of each introduced into the green fruit of a Bartlett pear.

The accompanying tables will show the kind of culture vessels used, the amount of culture fluid they contained, and the date at which each one was started. The first culture of the

| No. of Culture. | Date of Infection. | Kind of Culture Vessel. | Amount of Fluid. |
|-----------------|--------------------|---------------------------------|-------------------|
| 301 | March 27 | Salmon culture tube..... | 20 cc. |
| 302 | April 1..... | Salmon culture tube..... | 20 cc. |
| 307 | April 21..... | Sternberg culture flask..... | $\frac{1}{2}$ cc. |
| 309 | April 24... .. | Sternberg culture flask..... | $\frac{1}{2}$ cc. |
| 314 | May 22..... | Sternberg culture flask..... | $\frac{1}{2}$ cc. |
| 322 | June 5 | Test tube with Fol stopper..... | 25 cc. |
| 364 | July 13..... | Bartlett pear on tree..... | |

series was infected with a very small fragment of wood taken from the inner portion of a diseased limb of Flemish Beauty pear, in which the disease had been slowly advancing during the winter, from an inoculation made July 26, 1884, with an infusion of blighted twig from an apple tree. The infection of each of

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| 310 | April 27..... | Sternberg culture flask..... | $\frac{1}{2}$ cc. |
| 320 | June 5 | Test tube with Fol stopper | 25 cc. |
| 362 | July 13..... | Bartlett pear on tree..... | |

² Arthur, Bull. N. Y. Agric. Exper. Station, xcii: 3d Ann. Rep. N. Y. Agric. Exper. Station, p. 358.

³ Burrill, Amer. Ass. Adv. Sci., xxix, p. 589; *Amer. Naturalist*, xv. 529. Arthur, l. c.

the other cultures of the series was successively made with a small drop of the one preceding. From the last culture a drop was transferred to a puncture in a ripe Bartlett pear. In both cases the pears were soon filled with the disease. They did not turn brown about the wound, as is the more usual way, but first indicated the presence of the disease by beginning to shrivel, which occurred in one case in nine days after inoculation, and in the other in ten days. Upon cutting the pears open the softer tissues were found broken down and liquefied, and a milky viscid juice ran out, showing that the disease had taken thorough possession.

By this means of fractional culture the juices accompanying the bacteria first introduced were so much diluted in the transfers to succeeding cultures that the final drop used to inoculate the pear was practically free of them, and to the bacteria only, supplied by continued growth and multiplication, can be ascribed the last result.

Having shown that the bacteria when isolated from their juices are able to cause the disease, it still remains to show what action the juices would have when separated from the bacteria. On July 18 a strong infusion of blighted pear was filtered through a porous earthenware vessel, such as used for small electric batteries, and an unripe Bartlett pear inoculated with the filtrate and another pear with the infusion used for filtering. In a week the latter was thoroughly blighted, while the former showed no signs of injury except the slight wound, which finally healed. On July 24 another strong infusion of pear blight was filtered through a second battery cell. Both of these cells were new and had never before been used for any purpose. In this case two unripe Bartlett pears were inoculated with the unfiltered infusion and two others on the same tree with the resulting filtrate. Both the former showed strong evidences of the disease within three days, while the latter soon healed up the small wounds made by the inoculation, and have continued their normal growth.

The evidence is thoroughly satisfactory and conclusive. The bacteria accompanying the disease of trees known as pear blight when fully isolated will produce the disease, while the juices in which they live will not. They are therefore the direct cause of the disease.